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X-RAY OBSERVATORY REVEALS EXTREMELY DISTANT QUASARS

Scientists analyzing more than 500 images already received from NASA's High Energy Astronomy Observatory 2 (HEAO-2) have seen the brightest, most distant and most powerful objects yet observed to emit X-rays: quasars estimated to be more than 10 billion light years from Earth.*

The intense X-ray emission from the quasars, strange star-like objects that radiate inordinate amounts of energy for their apparently small size, suggests that they may contribute significantly to the widespread low-level background of cosmic X-ray radiation detected throughout the skies.

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* A light year is the distance light travels in one year = 9,600,000,000,000 kilometers (6,000,000,000,000 miles).

The discovery could have important implications for theories of cosmic evolution, for it would mean that the proposed mass necessary to "close" the universe is not present in the form of hot gas and, indeed, may be missing. The finding lends support to theories that the universe may expand forever.

HEAO-2, nicknamed "Einstein Observatory" after its launch on Nov. 13, 1978, is the second in a series of satellites designed to survey the sky in X-rays, an energetic form of radiation which is associated with some of the most powerful activity in space and yet is invisible to ground-based observers, having been absorbed by the Earth's atmosphere.

Einstein carries the first telescope capable of producing focused images showing the structure of X-ray objects. Previous experiments could only detect the approximate position and intensity of objects.

The distant quasars were discovered by scientists of the Smithsonian Astrophysical Observatory, Cambridge, Mass., using HEAO's high-resolution telescope in its so-called serendipity mode to make deep space surveys.

The objects appeared as bright point sources in otherwise featureless fields and, when compared with optical charts of the same sky regions, corresponded with extremely faint visual objects later identified as quasars by observations of their red shifts made by astronomers using the ground-based 4-meter (13-foot) Anglo-Australian telescope. Several of the objects had not previously been identified as quasars.

The most distant quasar detected through optical means is about 15.5 billion light years away. But with HEAO, scientists now believe they have the telescope sensitivity to detect quasars which are even more distant, or to determine that quasars more distant than 15.5 billion light years do not exist.

In addition to observations of quasars, the Einstein satellite has observed so called "normal" stars similar to the Sun, a class of young hot stars with strong X-ray emissions in their outer atmospheres, the remnants of supernovas, "cosmic bursters" in globular clusters, distinct sources of X-ray emissions in other galaxies much like our own, and the most distant clusters of galaxies yet observed by any instruments.

The observation of X-ray emissions from "normal" stars is expected to provide new clues to understanding the energy processes at work in the Sun. Previously, scientists had been able to study coronal emission of X-rays only in our own star. Now, the new observations allow comparative studies vital to explaining the mechanism that transports heat from the solar interior to its outer atmosphere.

A new class of stars observed by the Smithsonian team, known as O stars, are seen in the gaseous nebula Eta Carine.

These young stars, still in their early evolutionary stages, are buried so deeply in dust and gas clouds that they have been detected previously only by the infrared light irradiated by the surrounding cocoons of dust. The detection of X-rays from them is somewhat surprising. Some hitherto unknown mechanism, possibly magnetic bubbles in their atmospheres, apparently allows this high-energy radiation to dissipate.

At the other end of the evolutionary scale, several dying stars have been observed as X-ray sources, including the supernovae Cas A, Tycho, SN1006, Vela X and Crab.

A supernova is an explosion that occurs when a massive star is no longer able to offset the crushing force of its own gravity through thermal pressure generated by burning nuclear fuel. The star first implodes and then explodes, unleashing tremendous amounts of energy in the form of accelerated material and radiation. The out-rushing material may form a very hot shock wave as it sweeps up the surrounding interstellar material.

HEAO-2 observations of Cas A, Tycho and SN1006 show a complex X-ray shell structure and spectra, which are being compared to optical and radio data in order to develop a complete picture of the events that followed the supernova explosion.

For the Crab, which exploded in 1054 A.D., the X-ray emission is dominated by a pulsar -- a rotating, magnetic neutron star that uses the rotational energy of its mass to accelerate particles to very high velocities and then expels these particles into the surrounding medium. X-rays are observed from the pulsar itself, as are regular radio and optical signals every 30th of a second. X-rays are also observed as the high-energy particles interact with the magnetic field in the surrounding environment. In another pulsar observation, no X-rays are observed at all, thereby placing an upper limit of 600,000 degrees Celsius (1 million degrees Fahrenheit) on the temperature of the object. This result severely constrains models of pulsar emission.

Another early HEAO-2 observation may contribute to the resolution of a continuing controversy over the nature of the X-ray emission associated with globular clusters of stars.

The globular clusters, large spherical conglomerations of stars spread over our galaxy, have produced one of the more intriguing puzzles of the X-ray era. Intense X-ray sources, some of which switch on and off like cosmic lighthouses, have been observed in several clusters by earlier X-ray satellites.

Various theories have been proposed to explain these so called cosmic bursters, including the erratic accretion of gas onto a black hole and the presence of a binary system in which one member is a neutron star accreting gas provided by its stellar companion.

Preliminary data from the Einstein Observatory show the X-ray source in one such globular cluster to be located at the center of the cluster. If additional sources continue to be found so close to cluster centers, the sources each will be required to have a mass comparable to at least 30 suns, thus implying the presence of a black hole system.

HEAO-2 also has been able to make detailed studies of many normal galaxies and to identify distinct sources of X-ray emission in each. Particularly interesting is the galaxy M 31, a spiral galaxy similar to our Milky Way, which shows dozens of X-ray sources in the central bulge of the galaxy and also strung out along the spiral arms. The central bulge sources are oddly skewed to the galaxy's axis of rotation.

Previously, these extragalactic objects had been seen only as vague, blurry sources of X-ray emission; now it is possible both to chart the overall X-ray intensity of such galaxies and to map individual features in each.

The HEAO observation in X-rays of giant clusters of galaxies at distances comparable to the deepest view seen in optical wavelengths has important implications for theories of cosmic evolution. In addition to charting the distribution of these massive stellar conglomerations, the largest aggregates of matter known to exist, the observations may reveal the history of their formation.

It is still unclear if the clusters of galaxies formed directly from vast gas clouds at an early stage of the universe; or, if later, after the galaxies themselves had already formed, they were somehow bound together by gravitational processes.

The astrophysical plasmas studied with the Einstein Observatory are characterized by temperatures in excess of 10 million C (16 million F). At these temperatures, which are more than 1,000 times that of the ionosphere of the Sun, the light elements are completely ionized and, hence, are completely invisible. X-ray spectra and, in particular, emission lines from heavier elements which may be major constituents of these spectra, then become a unique means of probing the temperature, density, magnetic field and elemental abundances of the most powerful sources of energy in the sky.

Before the Einstein Observatory, only silicon and iron line emission had been identified in X-ray spectra. Scientists have recently detected, in the spectra of at least a half-a-dozen supernova remnants, thermal emission lines arising from highly ionized states of magnesium, sulphur, argon and calcium in addition to silicon and iron. Since heavy element synthesis occurs only in the latest stages of stellar evolution which culminate in supernovae, the emission that is seen is from freshly synthesized material. The abundances being measured, which appear to be very similar to Solar System abundances, are a direct confirmation of the idea that the Sun and planets were formed out of the debris from similar supernovae which detonated billions of years ago.

HEAO-2 has also discovered X-ray emission lines, arising from high temperature plasmas and/or the fluorescence from cooler material irradiated by X-rays, from a host of other exotic astrophysical systems: ranging from hot stars, through binary systems containing white dwarfs, neutron-stars or black holes, to the gas which permeates clusters of galaxies. Scientists are only just beginning to appreciate the implications of these new measurements on the detailed modelling of such systems.

In addition, our demonstrable sensitivity to X-ray line emission makes our failure to detect line features from other sources particularly significant. Quasars and Seyfert galaxies, for example, appear to totally lack significant emission features, as one would expect if the X-radiation is non-thermal in origin.

The Einstein satellite's observational program is operated for NASA by a consortium that includes the Harvard-Smithsonian Center for Astrophysics; Massachusetts Institute of Technology's Center for Space Research in Cambridge; Columbia University, New York City; and NASA's Goddard Space Flight Center in Greenbelt, Md.

The principal scientists are Dr. George Clark of MIT, Dr. Robert Novick of Columbia, Dr. Stephen Holt of Goddard and Dr. Harvey Tananbaum of Harvard-Smithsonian. Dr. Riccardo Giacconi of the Harvard-Smithsonian Center is the Principal Investigator with overall scientific responsibility for the program. Leon Van Speybroeck, of the same institution, designed the telescope optics.

A 6-centimeter (2.36-inch) high-resolution grazing incidence reflecting telescope forms the heart of HEAO's scientific package, and four separate instruments are located at the focus of the telescope and can be interchanged for different observational tasks.

Two image-producing instruments, a high-resolution television system and an imaging proportional counter, were designed by the Harvard-Smithsonian Center with hardware support from American Science and Engineering, Cambridge, Mass. A solid-state spectrometer and focal plane crystal spectrometer were designed by Goddard and MIT, respectively.

HEAO-2 was developed and is being operated for NASA's Office of Space Science by the Marshall Space Flight Center, Huntsville, Ala. HEAO-2 was designed and integrated by TRW, Inc., Redondo Beach, Calif., prime contractor for the series of three HEAO observations.

The Einstein satellite, operating only four months, already has doubled the number of known X-ray objects in the universe.

The rapid increase in the sensitivity of X-ray telescopes in little more than a decade is comparable, according to Dr. Giacconi, "to the 350-year evolution of the optical telescope from Galileo's crude refractor to the 200-inch Palomar reflector." Indeed, HEAO-2 has given X-ray astronomers a capability to produce images of the heavens with a sensitivity and accuracy equal to the best instruments in both optical and radio astronomy.

Dr. Giacconi first proposed the use of telescopes for X-ray astronomy in 1960. He and his group discovered the first X-ray star in 1962 and designed and operated the first X-ray observatory, Small Astronomy Satellite 3 (Uhuru), in 1970.

The HEAO-2 satellite was promptly tagged "Einstein" to honor the scientist whose theories of space, time and matter form the basis of much of the understanding of the high energy being studied by X-ray astronomy.

(END OF GENERAL RELEASE)

This information is also being released by the Smithsonian Astrophysical Observatory, Cambridge, Mass.

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GLOSSARY

Pulsars and Neutron Stars

Discovered in 1967, pulsars are stars which emit radio signals in extremely precise pulses. The bulk of available evidence suggests that pulsars may be fast-spinning neutron stars. These are compact bodies of densely packed neutrons (atomic particles having no electric charge), believed to form when a large star burns up much of its fuel and collapses. Containing the mass of a star in a sphere 16 km (10 mi.) in diameter, they are so closely packed that a spoonful of material from the center would weigh a billion tons.

Black Holes

These are believed to be the final stages in the collapse of a dying star. The star's material is so densely packed -- even more so than a neutron star -- and its gravitational force so great that even light waves are unable to escape. Black holes have been hypothesized but conclusive observations have not yet been possible.

Quasars

Astronomers are still baffled by the nature of quasars, but many believe that among observable objects they are the most remote in the universe. They look like stars when viewed through an optical telescope but emit more energy than the most powerful galaxies known. According to calculations, if they are as distant as many astronomers think they are, the total energy emitted by a quasar in one second would supply all of Earth's electrical energy needs for a billion years.

Radio Galaxies

Located on the fringes of visibility, radio galaxies emit radio waves millions of times more powerful than the emissions of a normal spiral galaxy. No one knows what these peculiar galaxies are. Several of them broadcast with such power that a sizable fraction of the nuclear energy locked up in their matter must be going completely into the production of radio waves.

Supernovae

Supernovae are large stars at their lives' ends whose final collapses are catacylsmic events that generate violent explosions, blowing the surface layers of the stars out into space. There, the materials of the exploded stars mix with other material of the universe (primarily hydrogen). Later in the history of the galaxy, other stars are formed out of this mixture. The Sun is one of these stars; it contains debris of countless others that exploded before the Sun was born.

There is strong evidence that supernovae (exploding stars) and pulsars are X-ray sources at some time in their history and that X-rays have been observed from radio galaxies and quasars.

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